August–September 1968

EMO

Prime Minister's Statement

Structural Dynamics Research

Radiological Protection Report

Municipal Emergency Operations

A Nuclear Analysis

CANADA EMERGENCY MEASURES ORGANIZATION

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In addition to publishing articles which reflect Canadian Government policy the Digest may also publish articles by private individuals on subjects of current interest to the emergency measures programme. The views of these contributors are not necessarily subscribed to by the Federal Government.

Editor: A. M. STRTON

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PRIME MINISTER'S STATEMENT

Extracts from Press Statement by

Right Honourable Pierre Elliot Trudeau

On Friday, July 12, 1968, the Right Honourable Pierre Elliot Trudeau, Prime Minister of Canada announced details of a re-organization of certain ministerial and departmental responsibilities.

With reference to Canada Emergency Measures Organization the Prime Minister announced, "The Emergency Measures Organization which now reports to the Minister of Industry, will report to the Minister of National Defence. Its role will be examined in conjunction with the Defence review presently in process".

The re-organization announcement dealt with the creation of new departments, re-allocation of departmental responsibilities, re-structuring, and amalgamations of government functions. Mr. Trudeau stated, "The re-organization has been guided by two basic principles. First, there is a need to provide a better structure to deal more effectively with new problems, and second, a need for each minister and department to concentrate on the areas of primary concern unhampered by matters which may better be handled in some other agency".

The Prime Minister also stated, "Some existing departments will be substantially re-structured, some departments will be amalgamated with others, and certain activities presently carried on in several departments will be concentrated in a single department. Some of the changes are designed to meet new problems, and to handle continuing problems more effectively; some, in addition, will produce substantial administrative savings".

A number of task forces, chaired by Treasury Board officers, will be set up to proceed with the implementation of these changes. Each task force will comprise a representative of the Public Service Commission, the Department of Public Works, the affected departments and the Privy Council Office. The task forces will report to a committee composed of the Secretary and Deputy Secretary of the Cabinet, the Secretary of the Treasury Board, the Chairman of the Public Service Commission and the appropriate Deputy Minister.

The Prime Minister emphasized that the changes being made are designed to deal with the problems as they exist or can be reasonably foreseen. The process should not and connot, however, be considered comprehensive and final. There must be a continuing examination with a view to making changes as the necessity arises.

STRUCTURAL DYNAMICS RESEARCH

by

W. A. Johnston

Introduction

Since 1960 Canada Emergency Measures Organization has been conducting studies and research to determine inexpensive and reliable methods of providing nuclear blast protection for the civilian population. The EMO National Digest reported in April 1961 on the development of blast shelter designs, and discussed the physical problems which must be solved in a successful design*. In October 1964 the EMO National Digest reported on experiments conducted at Defence Research Establishment Suffield, Ralston, Alberta, on blast shelters, blast doors and blast valves**.

Research in this area has continued to refine the tested designs and further experiments were conducted this summer on the latest versions of this equipment. The Mark II fibreglass reinforced plastic family blast shelter is much cheaper and simpler to build than the 1964 Mark I version. Preliminary reports indicate that the Mark II shelter provides more protection than the previous model. Fibreglass reinforced plastic blast doors intended for use in community blast shelters were tested with much simpler mounting hardware than was used in 1964. The blast valves tested this year are a new type developed and patented by Canada Emergency Measures Organization and Defence Research Establishment Suffield in 1966. These valves, installed in the shelter ventilation ducts, prevent the blast wave from entering the shelter. The blast valve tested in 1964 had a flapper which was closed by the blast wave and which, because of critical moving parts, proved to be expensive. The new blast valve tested this year has no moving parts. A chamber full of glass beads passes air easily at normal velocities, but high velocity shock waves produce so much turbulence around the beads that the blast wave is attenuated to a harmless level.

ABOUT THE AUTHOR

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While it is too early to report results and final analyses on these projects, considerable progress is being made and will be reported in a future edition of the EMO National Digest.

Designs for community fallout shelters which have a peacetime use have been prepared by Canada EMO. These designs have only nominal blast resistance and a study has been undertaken through Carleton University to design a blast-resisting roof which will have a peacetime value as a heavy structural floor system for the floor above the shelters as well as a protective capability against blast. The Carleton study is also directed towards the production of a design guide for blast-resisting roofs for commercial buildings.

In addition to studies on family and community blast shelters and accessories the Blast Protection Section has become increasingly interested in problems related to blast damage. This scientific interest centres on the manner in which blast produces damage, and the level of damage produced by a given level of blast. Studies are designed to have practical application in estimating blast damage for pre-attack planning and in developing methods or principles to reduce vulnerability to blast. This paper discusses the work of the Blast Protection Section in the reduction of vulnerability of Canadian physical resources, and in the prediction of damage to these resources in the event of nuclear attack.

In 1965, the Section separated areas of work into two departmental sub-programs called The Blast Protection Program which deals with the protection of people from the effects of blast, and the Vulnerability Reduction Program whose objective is the reduction of vulnerability of Canadian resources to the direct effects of nuclear weapons.

Research Activity in the Vulnerability Reduction Program

Research activity in this program has been concentrated on structures of ordinary types, such as apartment buildings, office buildings and factories. Normal structures such as these and their contents constitute the bulk of our national wealth which could be destroyed in an attack. Additionally, the destruction of a commercial building would mean the loss of life of many skilled employees as well as a temporary halt to the activity which took place in the building. The vulnerability to nuclear attack of electric powers systems, water systems, transportation systems, and other resources vital to national economy are planned for future studies.

* S.N. White, "Blast Shelters", EMO National Digest, April 1961, p. 7.

** Maier I. Zelman, "Report on EMO Projects in Suffield Tests", EMO National Digest, October 1964, p. 1.

Even after nearly 10,000 years of building development and construction, the behaviour of structures under certain types of loads or stress is not fully understood. In general, this has not led to unsafe buildings but rather to excessively safe buildings. Professor Ockleston of the Witwaterstrand University in the Union of South Africa reported on tests conducted in 1955 at the university. When a building was loaded to eight times its design load, it exhibited considerable stress but did not collapse. Professor Ockleston was not able to make it collapse in his tests. In civil engineering literature, a great deal of evidence has been presented to suggest that most buildings are considerably stronger than their designed strength would suggest. It is this reserve strength which gives conventional buildings the ability to resist blast loads. The problem in vulnerability reduction then, is to evaluate the reserve strength in buildings and determine ways to increase it.

Buildings can be divided into two general classes: First, are the structures whose loads are carried by walls, and classified as "load bearing". Most houses are typical of this type of construction as are many small commercial buildings and many apartment blocks. The second type of building of concern is the framed structure where loads are carried by a set of columns, beams and slabs. This type of building may be constructed of reinforced concrete or structural steel. This type of construction is commonly associated with high-rise office buildings, apartment buildings, almost all multi-storied commercial buildings and heavy factories. In framed structures, the walls, interior or exterior, are not load bearing and their contribution to the strength of the structure is generally neglected in the design of buildings.

The behaviour of the "load bearing" building, for example an ordinary residence, is exceedingly difficult to analyse. Fortunately, a fair amount of experimental data is available from atomic tests of the 1950s. While it is not possible to predict exactly the strength of a given building, it is possible to predict approximately

Figure 1. Unreinforced brick house after a nuclear explosion (5 psi over pressure).

Figure 2. Unreinforced brick house after a nuclear explosion (1.7 psi overpressure).

the load which will cause failure. Figures 1 and 2 show houses exposed to 5 lbs. per square inch and 1.7 lbs. psi at Nevada atomic trials. These values indicate the general range where "load bearing' structures fail. Load bearing structures of more massive construction fail at higher pressure levels than the examples chosen but, in general, their resistance to lateral load is not great.

The Response of Structures to Blast

This program deals with structures which were not specifically designed and built to resist the blast effects from a nuclear weapon at relatively close range. For buildings located at a distance from ground zero, the blast load on the building is essentially a horizontal or lateral load. Blast loading for normal structures, therefore, is similar to a high wind loading rather than the type of loading produced by a high snowfall. In addition, the load from blast is dynamic, that is, not constant. A dynamic lateral load introduces a number of interesting aspects to the problem of predicting the behaviour of multi-storied buildings. Tall buildings are capable of lateral or transverse vibration. The upper floors of the Empire State Building in New York City oscillate more than one foot under the influence of gusting winds. Shorter buildings also oscillate in a similar manner. The time required for one oscillation is called the period of oscillation. For normal buildings, this is about one-tenth of a second per floor of height. A 10-storey building, therefore, had a period of oscillation of approximately one second; while the Empire State Building of about one hundred floors has a period of oscillation of about ten seconds.

A typical blast wave has an over-pressure phase, that is, where the pressure of the wave exceeds normal atmospheric pressure, followed by a reduced pressure phase where the atmospheric pressure drops below normal atmospheric pressure. The time required for this cycle, which could be called the period of the blast

wave, tends to lie between five seconds and one minute depending on the size of the nuclear weapon. Thus we have a problem where a load whose period has one value acts on a structure whose period has a different value. This is equivalent to pushing a child in a swing not in time with the motion of the swing.

A modern type of load-bearing building is the reinforced concrete shear wall building. This building type is used for office buildings and apartments and is characterized by vertical concrete walls which may be interior or exterior which are continuous from the foundation to the roof. In many cases, the floors are installed after the walls have been constructed.

In 1966, Canada EMO asked McMaster University to investigate the vehaviour of reinforced concrete shear wall buildings subjected to lateral dynamic loads. McMaster University, using the technique used in all of Canada EMO structural research, developed a small-scale shear wall building and had used this small-scale building in its testing program. First, the model was tested with static or constant loads to determine its lateral strength.

This year, continuing its experiment program, McMaster University is constructing a simulator to dynamically test building models. The dynamic simulator is a device which induces dynamic loads on models and which can be programmed to simulate air blast, ground shock from blast or earthquake loading. The simulator operates by accelerating the base of the model in a programmed fashion. The simulator applies the equivalent of a blast load by utilizing the inertia of the mass of each of the upper floors to simulate the action of an external blast wave. This simulation can be quite exact as the relationship between the mass of each floor and the area exposed to the blast wave tends to be constant. Using a simulator of this type, it is possible to perform quickly, easily and cheaply, experiments exceedingly difficult in field trials. The studies on reinforced concrete shear-wall models at McMaster University are completely new and are already making a contribution to knowledge of structural engineering.

Many apartment buildings and most office and commercial buildings are of framed construction either in reinforced concrete or in structural steel. The response of framed structures to lateral dynamic loads is not well known. Canada EMO has in progress a number of studies on a variety of types of framed structures.

In 1966, McGill University was asked to investigate the behaviour of reinforced concrete frame buildings, including factory buildings and some types of commercial buildings where the structure is made of a system of columns and beams. The behaviour of the column beam connection is not adequately understood and considerable work has been carried out at McGill in the investigation of this critical zone of the building structure. The investigation is being carried out using small-scale models of reinforced concrete frames.

McGill University was also asked to investigate the strength of structures in reinforced concrete located at or below the surface of the earth and work is progressing on this study.

Many commercial buildings are constructed with a frame of structural steel. In 1965, Canada EMO began investigating the lateral dynamic response of steel framed structures using small-scale models fabricated from aluminum. Aluminum was selected because it is more ductile than steel and because its modulus of elasticity is lower. The greater ductility of aluminum allows greater deflections and deformations in the model before the metal fails and the lower value of the modulus of elasticity for aluminum simply means that it deflects a given distance with a smaller force. These two advantages make aluminum models easier to work with than equivalent models in steel.

Just as the beam column connections in reinforced concrete are the most difficult areas to understand exactly, the beam column connections in structural steel are also not fully understood. Canada EMO's Small Structures Laboratory conducted in 1965-66 a series of tests on bolted beam column connections and presented them in a Canada EMO technical report entitled Semi-Rigid Connections by M. Zelman and J. Liebeck.

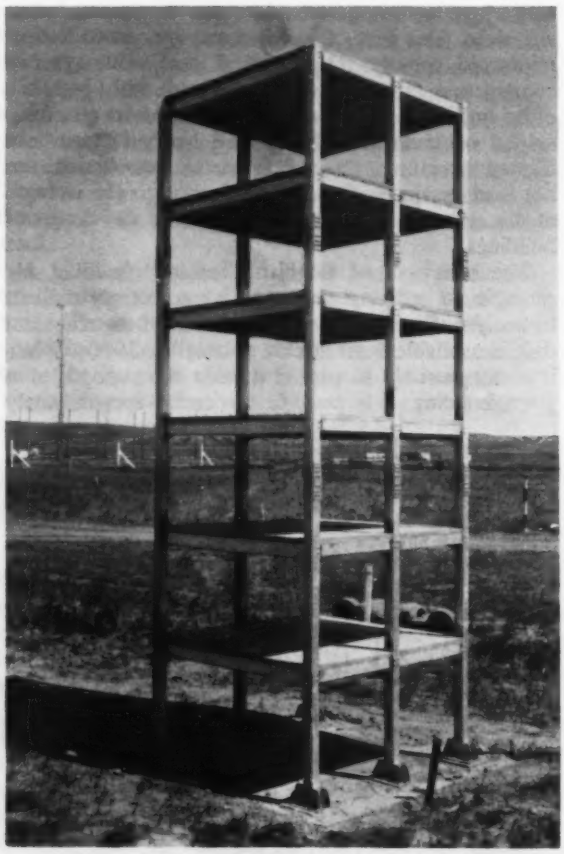

Figure 3

At the same time, the Small Structures Laboratory staff built a series of aluminum models with reinforced concrete floors. These were tested at DRES, at Ralston, Alberta, in their program of blast trials in 1966. Figure 3 shows the model before the blast. Another model was built in the Structures Laboratory of the Division of Building Research, National Research Council in Ottawa, and was tested there.

In 1967, the University of Calgary was asked to conduct dynamic tests on the aluminum framed buildings. A number of models have been built and tested statically and recently the University completed the construction of a dynamic simulator of a type similar to the unit constructed at McMaster University. Several models will be tested dynamically over the next few months.

Many structural steel buildings are now being constructed with welded connections and the University of Calgary has been asked to test model buildings using welded connections. Welding creates some problems since the relationship between aluminum and steel in bolted construction can be expressed as a constant; while the same relationship cannot be expressed for the welded structures. Welding changes the behaviour of aluminum in a somewhat different manner than welding changes the behaviour of steel. As a result, it will be necessary to produce small structural steel sections and construct models to adequately simulate the performance of the full-scale or real structural steel buildings.

Many commercial buildings and a fair number of apartment buildings are constructed with reinforced concrete floors supported on a series of reinforced concrete columns or "flat slab" construction. In 1967, the Small Structures Laboratory of Canada EMO fabricated a number of buildings of this type to investigate the behaviour of this type of building and to examine the increase in lateral resistance which is achieved by designing and constructing the building to resist the forces of earthquake. Two designs were produced in 1967 for this experiment. The first design was for normal loads only, that is, gravity and wind. The second design was for gravity, wind and Zone 3 earthquake loads as defined by the National Building Code of Canada (1965). These test models were designed as small structures rather than being scaled as, say, model aircraft or model trains are scaled.

The overall dimensions of four test buildings were derived by reducing to one-eighth the dimensions of a small apartment building. The models are 6′ by 7′6″ representing a building 48′ by 60′. Each model building is six stories high has a basement, and has 15 columns on each floor. Figure 4 is a photograph of one of the models. These models first were constructed in the Structures Laboratory of the Division of Building Research, National Research Council, and are being tested at this time. Figure 5 shows one model set up for testing.

Figure 4

The preceding portion of the research program could be defined as response studies. Each of these studies is relatively long term but is essential in development of methods for reducing the vulnerability of structures. However, it is necessary to get information for planning purposes more quickly than will be provided by these studies. This year, the University of Calgary was asked to carry out a literature survey of damage from dynamic load. Observations at Hiroshima and Nagasaki indicate that buildings designed to resist the effects of earthquake showed greater blast resistance than similar buildings which were not so designed. The University of Calgary, therefore, has been asked to compile information on damage from earthquake as well as from blast, and it is anticipated that this compilation will assist in a very pragmatic way in both the production of data for planning purposes and the production of information for the reduction of vulnerability.

Even with adequate understanding of the dynamic response of all building types, it is not likely to be practical to mathematically predict the behaviour of every structure of consequence under the effects of a nuclear attack. To make predictions with only a reasonable amount of difficulty, it appears necessary to develop a system whereby buildings may be classified according to their vulnerability to lateral dynamic loads. A consulting engineer in Toronto, was asked to evaluate the parameters under which a classification system could operate. This project will be completed in the near future, and it is expected that a simplified approach to the prediction of vulnerability will be developed which will make the acquisition of accurate vulnerability data economically feasible.

Building codes, for example the National Building Code of Canada, which contain provisions for earthquake, use as an approximation design technique the substitution of static lateral loads instead of a dynamic analysis of the building. This year, Canada EMO asked the University of Waterloo to examine the various dynamic design methods in use and develop a more accurate design technique. The existence of an

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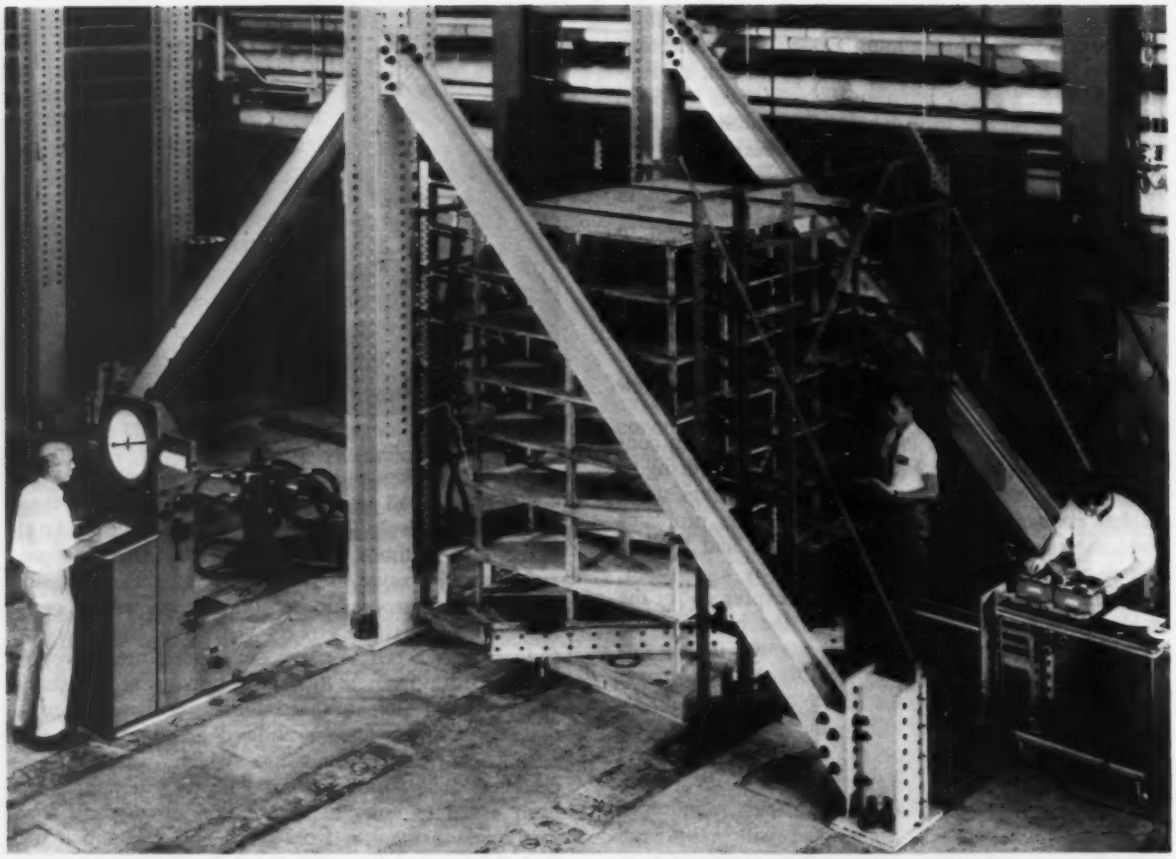

Figure 5

improved design method would tend to encourage creation of greater lateral dynamic strength in buildings, thus reduce the vulnerability of new buildings.

Another major research area in which the Blast Protection Section is carrying out work is to examine effect on structural performance due to variations in the strength of elements of buildings. The standard tests used in construction require that samples be taken from materials going into the building structure before the material is used. The tests, therefore, cannot reflect changes in strength which may take place after the sample is taken. In the case of concrete, the change in strength may be very significant. The effects of strength reduction in certain elements may be disastrous to the building under an overload of blast even though under normal load no distress is apparent in the structure.

Canada EMO conducted a study in 1967 on 10 buildings in the Ottawa area. In this study, the strength of concrete in columns was evaluated by measuring the velocity of sound through the concrete. Sample specimens were cast using the same cement and aggregates used in the buildings so that the relationship between the speed of sound and concrete strength for the concrete in these buildings could be determined.

Preliminary indications from this study are that substantial variations in the strength of individual columns do exist. While this study is regarded as preliminary, it is the first experimental investigation of this important problem in North America. A study of selected buildings in the Hamilton, Ontario, area is being conducted this year and a parallel analytical study to evaluate the effects of concrete strength variations on the vulnerability on the building is also being carried out during this year.

Canada EMO maintains close contact with the Division of Building Research, National Research Council, the Defence Research Board, and the Departments of Public Works and Energy, Mines and Resources. Facilities of these agencies and departments are used as required to obtain maximum output for the funds available for this program. The Structures Section, Division of Building Research, has allowed Canada EMO the use of their laboratory for the construction and testing of both the aluminum multi-storied models and the "flat slab" reinforced concrete models built by Canada EMO. The Testing Laboratories Division of the Department of Public Works has carried out all tests on the material components making up these models.

The Reduction of Vulnerability of Structures to Blast Loading

It has been noted that buildings designed to resist earthquake have tended to resist higher blast loads than similar buildings not so designed. Further, a substantial percentage of Canada's population live in seismically active zones. While few earthquakes of major catastrophic consequence have occurred in Canada, earthquakes of sufficient energy to produce disaster have occurred many times in the past 300 years. The Jesuit priests recorded terrifying earthquakes three centuries ago. As late as 1934, an earthquake shook the forest near Temiscaming, Ontario, and was felt over 300 miles away. In 1943, an earthquake occurred more than 20 miles underground below Morrisburg, Ontario. Fortunately, for Morrisburg, the great depth reduced the effect of the earthquake at the surface and only about $2 million damage was done. The intensity of the Morrisburg earthquake was higher than the 1964 Agadir, Morocco, earthquake which killed 40 per cent of Agadir's 33,000 inhabitants. The Agadir earthquake occurred less than two miles below the surface of the earth.

Since earthquake resistance in buildings tends to increase blast resistance and since much of Canada's populated areas are subject to seismic activity, a remarkable opportunity exists to promote reduced vulnerability to blast effects in nuclear war by encouraging aseismic or earthquake resisting design and construction.

An objective of the vulnerability reduction program is to achieve a reduction in vulnerability of normal structures at reasonable costs, and in this context we define normal as not specifically designed to resist the effects of nuclear weapons. It is not reasonable to contemplate the hardening of commercial buildings to resist the direct effects of nuclear detonation at close range. However, at a more extended range, the reduction in vulnerability which may be achieved by earthquake resisting design and construction and by a high level of quality control in construction, may make many structures which might otherwise be destroyed survive the effects of the weapon. The program objectives will, therefore, be fulfilled by the construction of better and safer buildings through the promulgation of the National Building Code. A level of preparedness for nuclear attack can, therefore, be achieved by the construction of dynamic resistance in peacetime.

The Analysis of Vulnerability

The value of the Vulnerability Reduction Program to the civil emergency planning program is the production of data for planning purposes. This paper has pointed out the fact that this data does not currently exist and that some will not be developed for a considerable length of time. However, it is necessary to carry on planning even if all of the data which is desired is not available. Vulnerability analysis may be considered a series of successive approximations where each generation of information will be more accurate than the best information previously available. A vulnerability analysis of certain buildings and systems will be conducted over the next few months based on the best information presently available including contributions from research work now being carried out. In about two years' time, the analysis will be revised as greater and more accurate research information become available from various related sources. A further complete analysis will be made towards the end of a five-year planning period to provide increasingly accurate information for planners.

Summary

Canada EMO is carrying out a program of structural dynamics research in Canadian universities and in its own Small Structures Laboratory with the assistance of several government departments and agencies. The research being carried on is a mix of long-term and short-term studies to give useful information for planners in the immediate future and to provide for better information later in the planning period. The information so produced has two uses. First, technical information will be made available to engineers and architects to promote the design and construction of less vulnerable buildings, and this reduction in vulnerability will be justified principally for its value in peacetime. Second, the information produced assists emergency planners in carrying out their tasks. ▲

U.S. 1969 PROGRAM EMPHASIS

From details contained in the Federal Civil Defense Guide, April, 1968.

The Office of Civil Defense announced program emphasis to guide State and local officials in developing their CD programs for fiscal year 1969. Program emphasis assigns priority to effort (manpower and funds) which should produce the greatest increase in lifesaving capability in the event of an attack on the United States. The basic aim is to make the best use of fallout protection existing in each locality. These priorities will be generally applicable toward a community's capability to operate effectively in nuclear attack or peacetime disaster. While the guidance is applicable on a nationwide basis, it is recognized that there

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RADIOLOGICAL PROTECTION REPORT

by A. H. Blake

Summary of the International Radiation Protection Association Meeting Interlaken, Switzerland, May 1968.

The following summary report was prepared for the Digest by Mr. A. H. Blake, Head, Nuclear Biological and Chemical Defence Section, Canada Emergency Measures Organization. Mr. Blake and Dr. Morley Whillans, Defence Research Board Liaison Officer, London, England, were the two Canadian delegates attending the seven-day meeting.

The International Radiation Protection Association, which is a world-wide association, sponsored by the World Health Organization, and established to make recommendations concerning the problems of nuclear radiation, held its meeting this year at Interlaken, Switzerland. Interlaken is situated at the foot of Yungfrau Mountain in the Alps, and is a favourite holiday location for visitors from all parts of the world.

On this particular occasion, there were indeed visitors from all over the world as 235 delegates from 19 nations met to discuss the topic of "Radiological Protection of the Public in a Nuclear Mass Disaster". While the meeting did discuss two incidents involving radiation hazards in a peacetime environment, the speakers concerned themselves with the many diverse and complicated problems which will present themselves following global nuclear war.

The study approached the requirement for protection by examining the problem and then by proposing certain remedial measures to alleviate it. The seven sessions included papers on the characteristics and behaviour of local fallout; the hazards which emanate from the deposition of fallout; the requirements for measurement of the hazard; analysis and interpretation of the measurements; protective and technical countermeasures; decision making and preparatory measures for survival and recovery.

The speakers on these subjects were selected by the organizers of the meeting from the most eminent in these fields. They included Professor Dr. Eugene P. Wigner, Nobel Prize Winner 1963, from Princeton University, U.S.A.; Dr. R. Scott Russell, Editor of "Radioactivity and the Human Diet", from the Department of Agriculture, U.K.; Dr. Carl F. Miller, author of the report "Introduction to the Long-Term Biological Effects of Nuclear War", U.S.A.; and Dr. George V. LeRoy, Chairman of the Sub-Committee for the U.S. National Committee on Radiation Protection from the Metropolitan Hospital, Detroit, U.S.A.

The delegates included specialists in radiation protection, radio-biology, radio-chemistry and staff members of military, civil defence, public health and agricultural authorities. Representatives from scientific and technical committees on radiation protection and emergency planning were also present. The nations represented included: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Holland, Italy, Japan, Yugoslavia, Norway, Spain, Switzerland, Sweden, United Kingdom, United States and West Germany.

The meeting did much to facilitate the exchange of opinions between the different branches of science represented at the meeting, such as physics, medicine, chemistry and biology. It also made scientists and civil defence planners, aware of the large gap which exists between the high degree of development of mass extermination weapons, and the modest degree of development in the means of protection against them.

The meeting also provided an interest to many young health physicists, and, it is hoped, convinced many of the civil defence authorities of the need and urgency to continue with these tasks by investment of greater financial, personnel, and material resources.

The meeting considered the problem of ingestion and inhalation of radioactive isotopes into the body, either by direct entry into the body or via the normal food chain. There was general agreement that concern about the internally deposited isotopes could be limited to four: Iodine 131, Strontium 89, Strontium 90 and Caesium 137.

By far, the greatest concern, however, was shown by all the specialists for the Iodine 131 problem and, especially, in relation to its effects on children. There is now sufficient data to show that radioactive iodine does have serious effects upon the thyroid in children, and that preventive measures can, and should be adopted in a radioactive fallout environment. Prevention or limitation of this hazard can be accomplished by providing quantities of powdered milk for the duration of the emergency; by the safe storage of food stuffs for cows; and by injections of stable iodine before the arrival of fallout so as to block the deposition of radioactive iodine in the thyroid gland. The adoption of these measures need be of a temporary nature only, that is, until Iodine 131 has decayed suffi-

ciently to permit the pasture feeding of cows. This might be about six weeks.

Most of the conferees agreed that it is necessary to develop some means of dealing with the biological recovery or the time-dose problem with regard to the radiation hazard. The need for such information is based on the knowledge that man does recover from the effects of radiation, but that the rate and manner in which this takes place are still largely unknown.

There was agreement, therefore, that to establish exposure limits for general post-attack emergency use is inadvisable. There is need, however, to provide the Civil Defence decision maker with guidelines and technical advice concerning the levels of radiation exposure in terms of total absorbed dose; the time over which the dose was absorbed; and the time since the dose was absorbed. This information will enable decision makers to weigh all factors equally and to make decisions with full knowledge of the implications involved.

To support this requirement, the meeting proposed that the medical advisers to the Association be asked to provide data which would indicate doses below which people would not become sick. It was felt that the times of interest to the Civil Defence authority are: one day, one week, one month and one year.

There was agreement by all conferees that the U.S. National Committee on Radiation Protection Report No. 29 "Exposure to Radiation in an Emergency" was in need of revision. This publication, which has been widely used by the Office of Civil Defense, postulates that recovery from the effects of radiation takes place according to *a formula developed by Dr. Blair of the United States. The meeting agreed that this formula can no longer be used as the basis for determining biological recovery in humans.*

There was, however, general agreement that an acute dose of 200 roentgens is the upper limit dose that will not cause sickness severe enough to require medical care in the majority of people. There is no doubt that there is still a great deal of uncertainty about the effect of radiation on man, and that medical authorities and scientists will continue their research into this very important subject.

It was recognized by Civil Defence planners that there has been lack of emphasis on analysis of structures with low protection factors. There is need for increased recognition by planners, and ultimately by the public, of the opportunities which exist for enhancing the degree of radiation protection in an emergency. To be effective for use by the general public, this information would have to be part of a general increase in understanding of protection from fallout radiation. It was felt that such a growth of general knowledge is vital to the success of any Civil Defence program. It was suggested that one means of achieving increased interest in Civil Defence activities would be to incorporate this training in the secondary schools' curriculum.

The delegates of the meeting concluded that some objectives of Civil Defence may only be attained after many years of planning and preparation. They reaffirmed that there is need to provide precise, concrete, realistic and practical recommendations for radiation protection, and that these recommendations should indicate:

—how and what to prepare before a nuclear disaster?
—how to react at the beginning of the disaster?
—how, what and where to measure; and by whom?
—how and who will interpret the results of these measurements?
—how to select the most adequate countermeasures?

The 1968 International Radiation Protection Association Meeting stimulated a new interest in the whole radiation problem. The nations represented benefited greatly from the interchange of ideas and the scientific data provided and will, it is hoped, be spurred on to produce effective radiological defence plans as part of the total requirement for emergency plans and operations. ▲

U.S. 1969 (*Continued from page 7*)

will necessarily be adaptations at the local level to reflect the actual conditions and state of development in the specific areas.

National program emphasis for FY 1969 specifies four major priority areas:

Priority 1—Community Shelter Planning; emergency operations planning (including increased readiness planning); work associated with the development of shelter; and appropriate training support for these items.

Priority 2—Direction and control (protected Emergency Operations Centers); attack warning system; emergency communications; radiological monitoring system; and appropriate training support for these items.

Priority 3—Supporting emergency functions—fire prevention and defense, law and order, rescue, emergency health and medical service, emergency welfare, resources management, public works, utilities, transportation—with appropriate training support, and supporting public education programs such as medical self-help and CD adult education.

Priority 4—All other work not specified herein or on local CD Program Paper. ▲

MUNICIPAL EMERGENCY OPERATIONS

Comment by A. F. B. Stannard, Scientific Adviser—Canada EMO

In 1963 the American Municipal Association under the title "Organizing Municipal Governments for Civil Defense" made a study in depth of the problems of organizing a capability for emergency operations at municipal level. The efforts in six cities were examined in detail and the problems of planning, organizing, financing, equipping and manning reviewed. The published summary of findings and recommendations is still so pertinent to present problems in Canada that it should be of immediate interest and value to anyone connected in any way with the municipal aspects of emergency planning. Of particular relevance are the sections on financial support and national policy.

Summary of Findings and Recommendations

City chief executives, administrators, and civil defense officials are not satisfied with the present condition of their civil defense readiness. They are almost unanimous in their desire for more positive direction and leadership from state and federal authority. They have experienced frustration in building their local civil defense programs because of rapid changes in national program and doctrine, the absence of effective state programs in many states, and, except during periods of unusual international tension, public apathy. Rapidly rising costs of local government, the need to provide increased services and undertake major programs of community development, and severely limited sources of revenue, have all combined to restrict the commitment of city resources to civil defense.

Problems of Organization

The municipal civil defense agency frequently has failed to establish an effective working relationship with the chief executive and operating, line departments of city government. Although the civil defense director always is responsible to the chief executive, the staff nature of the agency has been obscured and undermined by a number of factors. Basic misconceptions about the role of the agency have been created because of its increasing line activity and behavior, and its operational detachment from the chief executive. Department heads do not recognize the civil defense agency as acting in the name of the chief executive when it seeks to coordinate their emergency services and help them plan the assignment and utilization of their personnel and equipment resources or employ their departments to carry out peace time civil defense tasks. Contributing to this condition are the following:

The absence of clear directions by the chief executive establishing the staff relationship and continuing insistence that this relationship be observed in the administration of the program.

The use of volunteer civil defense directors and volunteer chiefs for key civil defense services, or the selection of city personnel of less than department head rank for direction and leadership of the civil defense program and emergency operations.

The failure to utilize existing appropriate city departments to carry out programs requiring major commitments of man hours of work such as shelter marking, stocking, and inspecting shelter facilities and supplies.

Mayors in commission and "weak-mayor" cities have inadequate control over large segments of the city services having critical emergency capabilities. Effective independence of department heads who are not appointed by the mayor.

The most unified and positive leadership for civil defense purposes was found in the two council-manager cities. This finding must be tempered by the observation that managers are reluctant to seek more than the most modest appropriations from city council for civil defense.

The optimum organization or assignment of city forces for civil defense purposes frequently may require a shift of agencies and staff within and between departments, out of the normal chain of command, to unfamiliar and weakly established command relationships.

Civil Defense emergency assignments are made too frequently on the basis of individual assignments rather than to organizations, offices, or agencies; and rosters continually are in need of revisions with which the civil defense staff does not keep pace.

Planning and Implementation

Civil defense planning goals have been aimed at a too-ambitious program of emergency services to attain successful implementation with the funds and level of

support from the regular city departments now available. City survival plans also have been too long and complicated in the past. Both the bulk and complexity of the plans have discouraged comprehension by city officials, operating units, and the general public. As a result, the plans have tended to demoralize or overwhelm city governments and reduce, rather than enhance, the possibility of building workable core programs.

Existing survival plans usually are obsolete and unworkable, and yet they remain officially in effect. Annexes are also obsolete and revisions are being anticipated or commenced without revision of the basic survival plan on which they should be based.

There are deep divisions of opinion within municipal civil defense staffs and within the administrative and legislative branches of city governments concerning the efficacy of the shelter program as opposed to evacuation, or even no program at all. Cities where evacuation is a credible alternative to fallout shelter have been discouraged by the present emphasis on fallout shelter planning and implementation to, what many local officials feel, is the sacrifice of all other programs.

The existing professional staffs of city operating agencies are not being utilized to develop civil defense plans and annexes to the extent that is desirable. For example, the professional staff of planning agencies are not being used to develop shelter utilization plans.

Survival and emergency plans have been developed by public utilities, industries, businesses, federal facilities, and other governmental and community organizations. Little coordination of these plans with the city plans is apparent in some cities. The implementation of many of these plans is more advanced than the city program.

Training

City personnel, from mayors and councilmen through administrators and down to the rank and file employee, have not been kept informed about the shelter program as it has been developing, and they have not received orientation or briefing about the facts of nuclear conflict from which the program has been generated or the plans to meet this threat. These people are little better informed than the general public. Except for the uniformed services, the average employee does not recognize that he has a responsibility to serve his community during an emergency caused by a nuclear attack on the country.

Students returning from the federal civil defense instructor training courses seldom have been used as instructors in municipal training programs which have been sporadic and, at times, poorly organized and attended.

The training of radiological defense teams and radiological monitors has made a significant start, but as yet, equipment is not in position and calibrated and personnel are not available for all the stations required. There is concern that personnel already trained may be lost to the program if these conditions are not corrected.

The training of shelter managers at the municipal level has made almost no progress, as yet, City civil defense staffs and resources are inadequate to carry out successfully a program of such magnitude and critical importance.

The special training given volunteer and auxiliary forces in the past has served to sustain the interest and participation of these people in the program for a time, but eventually they have drifted out of the program because of continued inactivity or less of a feeling of urgency, and the end result has been a waste of training effort.

Classroom courses for the general public in first aid, basic civil defense survival, or civil defense orientation, are not productive enough in terms of the number of people reached to justify the efforts already being expended. Special civil defense courses presented by organizations with continuing programs not dependent upon civil defense have been more successful.

Manpower

It was found that the civil defense agency was undermanned in cities under 250,000 population. In cities with populations over 250,000, it would appear that an adequate staff was obtainable, but the shifting climate of public opinion and the estimate made of that opinion and appreciation for the need of the civil defense program by city council is critical. Additionally, salary scales are too low and funds too limited in the small cities under 50,000 to retain a professional, full-time civil defense director and a capable staff.

The federal personnel and administrative assistance program was of minor benefit to the majority of the municipalities studied. The conditions, or alleged conditions, attached to this assistance inhibited its utilization to the point where meaningful improvement of the civil defense staff had not been accomplished. Many times, personnel not officially attached to the civil defense staff were being used for the accomplishment of civil defense tasks. No attempt had been made to secure personnel and administrative contributions for these people.

Municipal forces, with the exception of the departments of health and welfare, appear to be adequate for the program in terms of their operational capability in cities over 100,000 population. A break occurs somewhere between 50,000 and 100,000 population, at which point the forces become too small in most services to meet the requirements of either the fallout shelter program or effective post-attack recovery operations.

Cities have utilized their existing forces only partially in civil defense preparations. The staff agencies, departments of health and welfare, departments of parks and recreation, the city engineers office, and

department of public works, are example of agencies which have not been utilized fully to date. Most of the personnel do not have civil defense assignments, nor do they have agency tasks to carry out in emergency situations. Agency directors repeatedly indicated that no thought had been given to their agency's contribution to the civil defense effort.

Full-time city health and welfare personnel are too limited in number to serve as a base for organizing a civil defense medical or welfare activity. Welfare and health departments either do not exist, or their staffs and the peace time functions they perform are too limited to carry out the planning and operations tasks expected of them. Assignment of these functions to existing country agencies did not fill these gaps in the program because of the lack of county activity.

Programs to develop volunteer and auxiliary forces have been unproductive. It is too difficult to recruit, train, and retain these people over long periods of time and inactivity. The major effort expended on these programs has been wasted to a great extent. The use of established community organizations like the Red Cross and Salvation Army on the other hand, should be promoted even though their forces may be largely volunteer, because their programs are such that continued interest on the part of the volunteers can be sustained.

Cities have not made calculations of the forces needed for emergency operations, or made inventories of where the augmentation of city forces can be obtained.

Equipment

City construction equipment, in most cases, is too limited for recovery operations without augmentation from private contractors. Arrangements for emergency service with the city's regular contractors have not been formalized and the need for such arrangements on a pre-attack basis is not considered of high priority by the cities in the development of their local programs.

The vehicular and mass transit equipment now available to cities is more than adequate to implement a movement to shelter if its utilization is fully planned.

Radio equipment appears ample for essential control of emergency activities. However, little of this equipment has fallout protection and it may rapidly become inoperable. There appears to be an over-emphasis on RACES and Citizen Band radio manned by volunteer amateur operators in the total communications program. The reliability of these resources is open to serious question.

It is unlikely that there will be a significant municipal augmentation of the basic shelter supplies provided by the federal government. The idea of providing variety in the food diet, cooking facilities, auxiliary lights, cots, blankets, and, of course, games, is scorned by most local officials as unrealistic and unnecessary. At this time it is evident that a shelter stocking program has a chance of successful local implementation only if it remains on the most austere basis.

Shelter Availability and Utilization

Cities under 100,000 population have inadequate shelter for their people. Cities under 50,000 population have so little shelter available that the shelter program itself does not appear credible to the officials of these cities.

Cities between 100,00 and 250,000 population should be able to move a substantial portion of their population to shelter in one movement. This is possible on the planning assumption that the city will not be an immediate target and some vehicular movement of people would be possible.

Cities over 250,000 population should plan for a two stage shelter movement. The first stage should be planned to move people to the best available shelter no more than one mile from their location, and the second stage should be a post-attack movement of inadequately sheltered people to shelter with higher protection factors.

Many cities, states, and federal regional offices have no emergency operations centers with fallout protection. This condition must be corrected so the sheltered population would not be without leadership during and after the shelter stay period.

Financial Support

Municipalities are experiencing severe public pressures for an end to rising local taxes and for a leveling-off of municipal expenditures. Employee demands for salary increases are becoming more intense, and the difficulty in finding qualified personnel will necessitate meeting these demands. City policy makers regard the civil defense program as important but the remote threat of war is not sufficient to give the program a priority claim to city funds in competition with more popular and pressing programs which yield an immediate and obvious benefit to the city. Significant increases in civil defense expenditures are unlikely, and the program is very vulnerable to reduction in its budget whenever there is a relaxation of international tensions. Although it was not explicitly stated by city officials, federal financial contributions and guidance must be greater than they have been in the past if the cities are to develop and maintain their shelter systems on a ready basis.

Metropolitan central cities with substantial civil defense capability, a surplus supply of shelter, and large non-resident working population, feel, with some justice, that the costs of their program should be shared on a regional basis.

Officials in cities with little or no shelter available believed that the federal shelter incentive program is a first requirement if they are to continue to support civil defense locally. In the absence of any shelter facilities, or few shelter facilities, there is little incentive for them to develop a civil defense capability.

State and federal reluctance to appropriate the funds needed for the adequate support of the civil defense

program at their levels has a pronounced effect on the local effort to finance the program at that level. Whenever a state program is weakened, whenever Congress rejects a phase of the civil defense program presented them, local government officials tend to interpret this as justification for their inaction locally.

Legal Problems

There are no substantial legal impediments to an effective civil defense program at the local level. Several areas, however, should be given more attention by local governments. They are:

Succession to all key administrative offices should be provided in depth.

Special emergency provisions for filling vacancies on council should be obtained by amendment of city charters.

Charters should be amended to permit emergency sessions of council, the passage of ordinances by an abbreviated procedure and their passage by a majority of a reduced quorum.

Standby ordinances should be enacted authorizing the city to make emergency requisitions and regularize procedures for the taking of private property both in shelter and during periods of emergency recovery operations.

Cities have not provided for the uninterrupted continuation of either the judicial function or the legislative function through a disaster or shelter period. In most cities, judicial continuity cannot be provided for by local government because the courts are a county or state instrumentality and not a part of city government. Common opinion was expressed that neither of these functions is necessary in an emergency and, in some cases, would only serve to complicate and confuse the command and direction of emergency operations.

Cities have not made adequate provisions for records preservation nor have they consulted the city attorney to advise them concerning the legal requirements of their records preservation program.

City solicitors or law departments have not been consulted in formulating emergency plans, nor have these plans been submitted for systematic review by the attorneys. Officials react to this problem by taking the position that in an emergency, no one is likely to resort to legalisms, and if they do, the matter will be settled long after the recovery phase is over. Anticipating these problems in a "frill" not necessary to the progress of the program.

Intergovernmental Problems

There is a need for closer liaison and more guidance from federal regional offices and state offices of civil defense. In those cases where the state civil defense staff is totally inadequate to give the guidance and service needed by the municipality, the federal regional office should be authorized to act directly with the municipality.

There is a need for an area-wide approach to planning shelter systems for entire regions. Workable plans are not feasible for each separate municipality in heavily conurbated areas. Existing mutual aid plans are not adequate or realistic for metropolitan areas because their voluntary nature makes them unreliable in emergency situations and they offer no satisfactory substitute for unified, area-wide command. The efforts of suburban governments to carry out their civil defense responsibilities were not studied in detail, but the cities invariably were critical of the efforts made by their smaller neighbors.

When an emergency function was assigned to the county civil defense agency, or a county department, the county lagged far behind in the city in the development of its program—and left large gaps in the city's readiness posture that could not be closed.

School districts have not been included in civil defense planning, nor have they been given directions or briefing in civil defense policies to the extent they should be. Inconsistencies between school emergency plans and the city's survival plans are of critical importance and should be reconciled.

National Policy Considerations

In some states, cities that could develop effective civil defense capabilities have been hampered by the failure of the state to create a capable and adequately staffed state office of civil defense. The federal policy of working only through the states rather than directly with municipalities has meant that cities in states with substandard programs have fallen far behind cities in states with good programs.

More positive federal guidance, especially in the establishment of priorities within the civil defense program, would permit units of local government to concentrate their efforts on a core program, rather than spreading their efforts over too wide an area as they are now doing.

The results of state and local training efforts suggests that the federal government should develop a program of end product training as opposed to instructor training for those courses oriented toward special civil defense services such as radiological monitoring, shelter management, or shelter coordinator.

No city agency may be adapted readily to plan for and effectively carry out a program of immediate post-shelter rationing of food, clothing, and allocation of critical supplies such as fuel, gasoline, and medicine. Existing city departments have the needed administrative personnel and clerical personnel to undertake a program of this kind. They must, however, be given a completely planned and packaged federal program and cannot be expected to improvise one on their own initiative.

The present pattern of local civil defense organizations based upon each unit of municipal government

(*Continued on page 19*) **MUNICIPAL . . .**

A NUCLEAR ANALYSIS

by
Kenneth Gatland

The Canadian Magazine, May 4, 1968, published an article on the world nuclear threat under the title "You Have Seven Minutes to Live". Exclusive publication rights for North America were obtained by The Canadian from the Daily Telegraph Magazine, London, England.

The Digest thanks the author, the Daily Telegraph Magazine and The Canadian, for permission to reprint the following article.

ON THE COVER of each issue of "The Bulletin of The Atomic Scientists" is a doomsday clock. The hands stand at seven minutes to midnight. They were advanced five minutes in January after being at 12 minutes to midnight since 1963. Dr. Eugene Rabinowitch, the editor, says the change marks the wars of the past five years, the race to produce anti-missile systems and the dismal record of countries reverting to narrow national interests.

The warning comes as a chill shock to a world that accepts as normal an environment in which security depends on the threat of nuclear destruction.

Though it may be claimed that the fear of mutual annihilation has subdued a number of East-West crises, there is no guarantee that one day—either by accident or miscalculation—our species will not die in thermonuclear battle.

There is no lasting solution in the deterrent. At best it provides mankind with a breathing space from which hopefully, it will evolve a new maturity.

Now, new dangers are on the horizon. Already France and China—both about to add nuclear missiles to their arsenals—threaten to disturb the power balance between East and West, lessening the degree of manoeuvrability available to Russia and the United States in avoiding thermonuclear war. Britain, too, soon will have four Polaris-launching submarines to back up her force of V-bombers. These, at least, will operate as part of a NATO force, though theoretically they can be withdrawn for independent use.

Other nations are beginning to produce fissile material (plutonium)—which could be used in weapons—as a byproduct of peaceful atomic power stations. In this category already are Canada, Czechoslovakia, East and West Germany, India, Israel, Italy, Japan, Pakistan, Spain and Sweden.

The new enthusiasm of the superpowers for a nuclear non-proliferation treaty reflects the growing anxiety. Although the treaty will be signed by a fair proportion of countries, it will not deflect the nuclear ambitions of France and China. If China in particular maintains her present course, the Seventies could be dangerous years indeed. And any hopes for a step-by-step arms reduction between Russia and the United States will be frustrated.

The models on page 15 show the scale of the nuclear arms race as it will appear around 1970. The destructive potential available to the United States alone boggles the imagination.

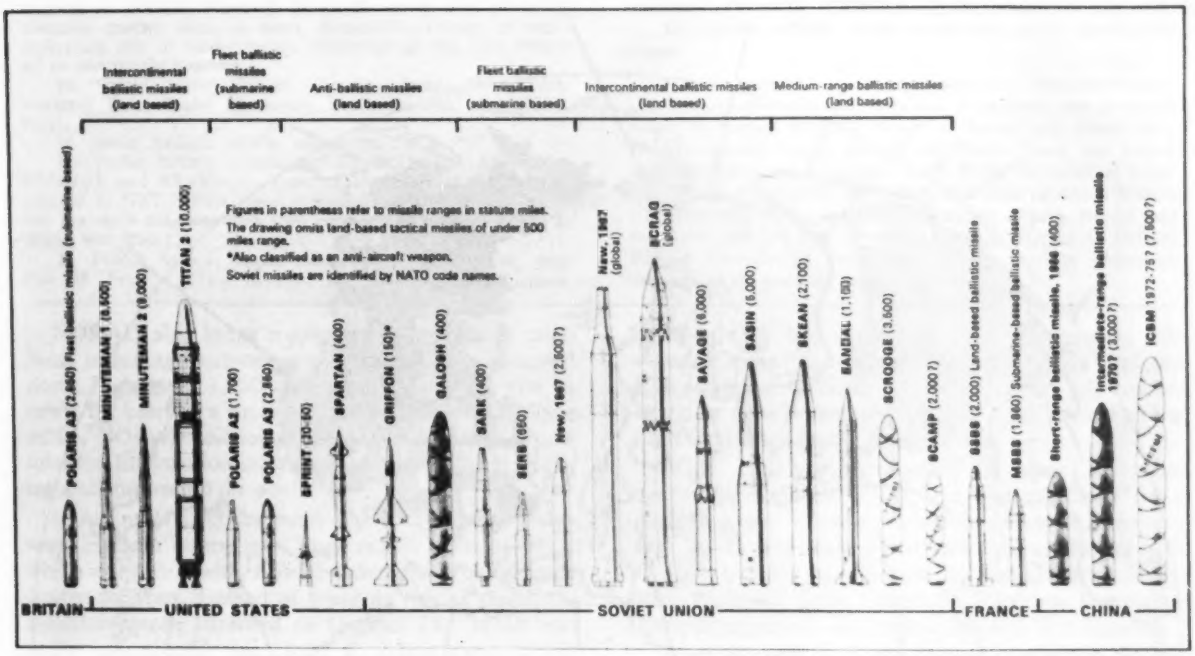
Concealed in underground silos throughout the prairie states of Montana, South Dakota, Missouri and Wyoming, are 1,000 Minuteman intercontinental ballistic missiles (ICBMs). In Arizona, Kansas and Arkansas are 54 heavyweight Titans. Each ICBM complex has its own underground command centre manned 24 hours a day. And each missile in an "alert" conditions has an H-bomb warhead allocated to a specific target.

Backing up the land-based missiles are about 600 long-range bombers, along with 41 nuclear submarines that are armed with 656 Polaris missiles.

U.S. forces alone carry 2,200 weapons averaging over one megaton each, according to Robert McNamara, the former U.S. defence secretary. A megaton is the explosive equivalent of one million tons of TNT. Only 400 weapons of one megaton are sufficient to destroy over a third of Russia's population and half her industry.

On the other hand, Russia is thought to have 500 ICBMs and over 700 medium and intermediate range missiles for use against Western Europe and to protect her immense frontier stretching from the Black Sea to the Sea of Japon. On average, Russia's missiles are larger and carry a heavier nuclear punch, which tends to offset the U.S. superiority in numbers. Russia has fewer strategic bombers than the U.S.—McNamara estimates about 155—but increasing effort is going into the development of missile-launching submarines.

Yet despite the awesome destructive power in the hands of each country, neither could knock the other out so completely in a first strike as not to receive a thermonuclear counterblow. The U.S. determination to have clear warning of any nuclear attack is portrayed by the world diagram illust No. 2. The dotted line straddling Britain, Greenland and Alaska, represents the Ballistic Missile Early Warning System (BMEWS), with its stations at Fylingdates, Thule and Clear. The powerful BMEWS radar can detect a missile 3,000 miles away, giving Britain four minutes warning of attack and the United States 15 minutes.



Ballistic Missiles of the Nuclear Powers

Type of Ballistic Missile	*Inter-Continental*	*Intermediate (Land-Based)*	*Submarine-Launched*	*Status*
USA	1,054	—	656	Operational
USSR	720*	750	125	Operational
BRITAIN	—	—	64	1968-70
FRANCE	—	50	64	1969-76
CHINA	?	?	?	1970s

** Previous estimates of Soviet ICBMs were 520-550 by mid-1968.*

U.S. and USSR intercontinental missile strengths are those reported by the Department of Defence as of October 1, 1967. All U.S. ICBMs are silo-based for protection against enemy attack. Many Soviet missiles are silo-based; some (e.g., Scamp and Scrooge) are mobile on wheeled or tracked vehicles allowing maximum concealment.

Britain will have 64 Polaris missiles in four submarines in 1970—the first 16 this year.

France will have 27 to 50 land-based missiles operational in 1970, plus 64 in four submarines in 1976 (first 16 in 1970).

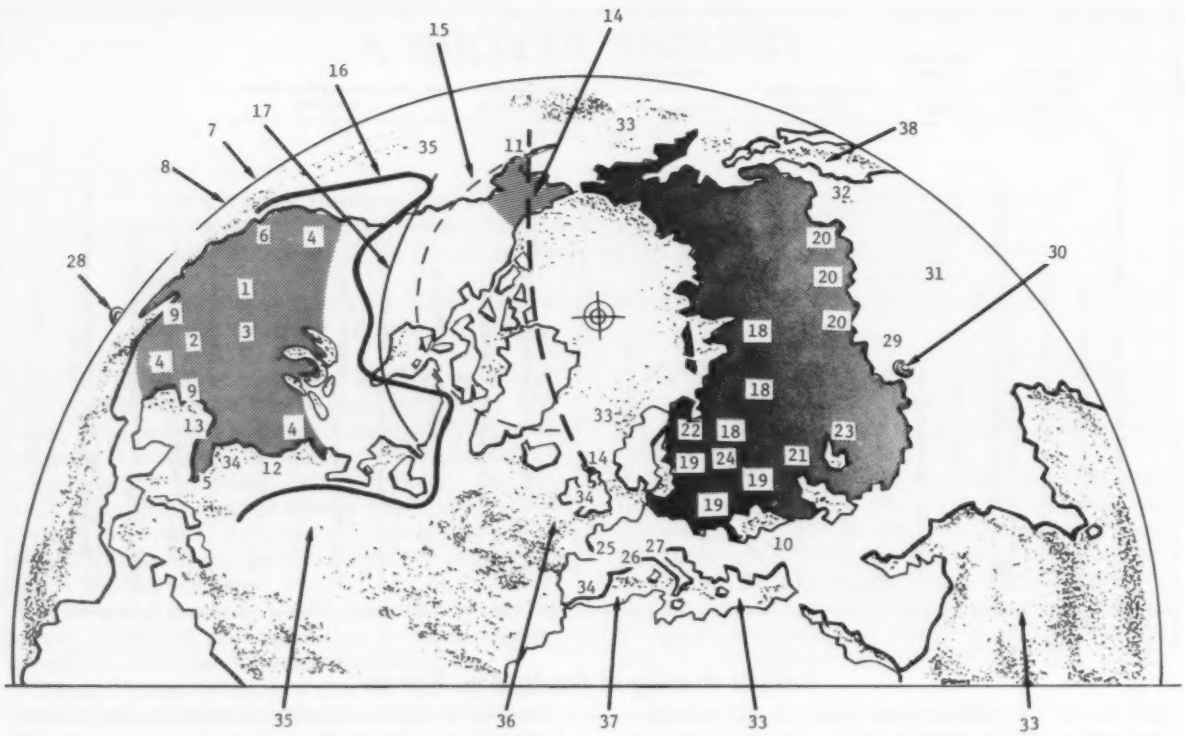
China may have her first medium-range ballistic missiles by 1969 and a modest operations force by mid-1970. ICBMs could be operational by 1972-75, submarine-launched missiles earlier.

Not represented in the precedent are smaller battlefield nuclear missiles, long-range bombers (U.S. has 697 and USSR 155) and tactical strike aircraft carrying nuclear weapons.

Such warning is transmitted automatically to the combat operations centre of North American Air Defence Command (NORAD), housed in a subterranean complex of steel buildings burried 1,400 feet inside Cheyenne Mountain, near Colorado Springs. Information is also flashed to the headquarters of Strategic Air Command, the Pentagon in Washington, and the National Defence Headquarters in Ottawa.

The heavy black line on the chart represent the radar network guarding against manned bombers. It covers the United States and Canada and is extended out to sea off both coasts by radar aircraft. Farther north, on the edge of the continent, is the Distant Early Warning line, which extends from the western portion of the Aleutian Islands across Greenland.

It is at NORAD's computerized nerve-centre in Cheyenne Mountain that a developing nuclear attack against the western world would be monitored, allowing the United States to deliver her calculated response before the first wave of enemy missiles arrive.



The Strategic Balance

1. Combat Operations Centre, North American Air Defence Command (NORAD), Cheyenne Mountain, near Colorado Springs.

2. Titan 2 ICBM sites. Total of 54 missiles in underground silos at Davis-Monthan Air Force Base, Arizona; McConnell AFB, Kansas, and Little Rock AFB, Arkansas.

3. Minuteman 1 and 2 ICBM sites; total of 1,000 missiles at Malmstrom AFB, Montana; Ellsworth AFB, South Dakota; Minot AFB, North Dakota; Whiteman AFB, Missouri; Warren AFB, Wyoming, and Grand Forks AFB, North Dakota.

4. Sentinel anti-ballistic missile sites operating Spartan and Sprint (fully Operational 1973): Albany, Georgia; Chicago; Dallas; Grand Forks AFB, North Dakota; New York; Honolulu; Salt Lake City; Seattle; Boston; Detroit, and ten other centres yet to be announced.

5. Kennedy Space Centre, Florida. Satellite launching and missile test.

6. Vandenberg Air Force Base, California. Satellite launching and missile test.

7. Satellite interception system (Thor-based) under NORAD, Johnston Island, Pacific Ocean.

8. Satellite interception (Nike-Zeus based) under NORAD, Kwajalein Atoll, Pacific Ocean: Also Sentinel anti-missile test.

9. Space Surveillance System (U.S. Navy) "electronic fence" for satellite detection (part of NORAD's Space Defence System). Transmitters (silver fans) at Gila River, Arizona; Kickapoo Lake, Texas, and Jordan Lake, Alabama; receivers (blue) at San Diego, California; Elephant Butte, New Mexico; Silver Lake, Missouri; Fort Stewart, Georgia; Red River, Arkansas, and Hawkinsville, Georgia.

10. Tracking station of NORAD's Space Detection and Tracking System at Dirjarbakir, Turkey.

11. As above at Shemya, Alaska.

12. As above at Moorstown, New Jersey.

13. Advanced south-looking radar for missile and satellite detection at Elgin Air Force Base, Florida. Part of NORAD's Space Detection and tracking System.

14. Ballistic Missile Early Warning System (BMEWS) stations at Clear, Alaska; Thule, Greenland, and Fylingdales, England. Clear and Thule operated by USAF's Air Defence Command; Fylingdales by RAF Fighter Command.

15. Distant Early Warning (DEW) line of radars for aircraft advance warning (NORAD).

16. Pinetree radar system for aircraft advance warning (NORAD).

17. Mid-Canada line of radar for aircraft advance warning (NORAD).

18. Soviet ICBM sites, some with large missiles in underground silos.

19. Soviet intermediate range ballistic missiles (silo-based and mobile).

20. Soviet intermediate range ballistic missiles (mobile).

21. Soviet Kapustin Yar cosmodrome (small satellite launching).

22. Soviet Plesetsk cosmodrome (satellite launching).

23. Soviet Tyuratam-Baikonur cosmodrome (satellite launching and missile test).

24. Soviet anti-ballistic missile sites, armed with Galosh, near Moscow and other centres.

25. French Centre d'Essais des Landes (CEL), near Biscarrosse. Missile test area.

26. French atomic centre at Pierrelatte.

27. French site on Plateau d'Albion for SSBS missiles.

28. Centre d'Expérimentation du Pacifique, Fangataufa Atoll. French atomic test centre in Polynesia.

29. Chinese rocket range in Sinkiang Province.

30. Chinese atomic test centre at Lop Nor, Sinkiang Province. (Seven tests 1964-67; nuclear October 16, 1964; May 14, 1966; May 9, 1966; October 27, 1966; December 28, 1966; thermonuclear June 17, 1967; nuclear or "dud" thermonuclear December 24, 1967.)

31. Chinese gas-diffusion plant making enriched uranium (U-235) for weapon tests at Lanchow.

32. Chinese missile submarine prototype reported at Dairen.

33. United States' ballistic missile submarines. Total of 41, each with 16 Polaris A2 or A3; 34 assigned to Atlantic, Norwegian Sea and Mediterranean, seven to Pacific (three Med. submarines

assigned to NATO). Normally 21 or 22 at sea and 10 to 11 alongside mother ships at bases. Remainder—average of ten—undergoing refit or modernization. Eventually all will have Polaris A3 or new missile Poseidon.

34. United States' Polaris submarine bases: Holy Loch, Scotland; Rota, Spain; Charleston, South Carolina; and Guam, Pacific.

35. Soviet ballistic missile submarines.

36. British ballistic submarines, RESOLUTION, RENOWN, REPULSE and REVENGE. Total of four with 16 Polaris A3; assigned to NATO. First vessel commissioned 1968 (Each submarine has more firepower than total conventional explosives used in World War Two.)

37. French ballistic missile submarines. Total of four, each with 16 French MSBS missiles: LE REDOUBTABLE (commissioned 1970): LE TERRIBLE (1972), other 1974 and 1976.

38. Chinese ballistic missile submarines (early development phase).

Not represented here are new American "over-the-horizon" radars to increase advance from the ionosphere; also perimeter radars to support guidance radars of anti-ballistic missile sites. Western Europe, easetrn Europe, and Soviet Union also possess extensive radar defence systems. In the USSR the so-called Tallinline guards northwestern perimeters and other extensive systems cover particularly the northern approaches, eastern Europe and the Middle and Far East. A massive NADGE (NATO Air Defence Ground Environment) radar chain is being built to supplement existing NATO facilities in western Europe.

NORAD also keeps a running record of all satellites, including burn-out rocket stages and discarded parts. More than 1,200 man-made objects are now in orbit. By keeping a precise count and calculating their orbits, NORAD can tell when Russia launches a new satellite. Information streams in constantly from tracking stations around the world.

A recent U.S. government report tells of an awkward moment during the Cuban missile crisis of 1962, which coincided with Russian attempts to send space probes to Mars. Instead of breaking free of the earth, the Mars probe launched on October 24, "broke into many pieces, and this cloud of debris came within range of the BMEWS radar defence which saw what might for a moment have looked like a mass ICBM attack. The computer must have quickly revealed it was not, but the potentialities for misunderstanding were there."

Today orbital weapons are more realistic. Only last year, McNamara claimed that Russia was developing a Fractional Orbit Bombardment System. While conventional ICBMs would arch some 800 miles into space over the Northern Hemisphere before plunging on their targets, orbital weapons could be sent into low orbits of only 100 miles' altitude to enter the U.S. through the back door of the South Pole.

Helping to plot the satellites is an electronic fence that stretches across the southern states from Georgia to California. Three powerful transmitters at Gila River, Arizona, Kickapoo Lake, Texas, and Jordan Lake, Alabama, send out a continuous fan of radio energy reaching thousand of miles into space. A satellite—transmitting or not—has only to cross this "fence" for its position to be rapidly computed.

An impressive new south-looking radar installation at Eglin Air Force Base, Florida, has recently joined the space-track network. This adds enormously to the satellite data. Nearly all earth-orbiting objects pass through its viewing field at least twice a day.

Yet for all this (and much more that is secret) the U.S. could not prevent wholesale devastation in a thermonuclear war with the Soviet Union. Anti-ballistic missiles—nuclear missiles to destroy ICBMs—might provide the answer against a relatively unsophisticated attack from China in the Seventies; but the missile swarms that Russian could unleash—complete with multiple warheads, decoys and other penetration aids—would quickly swamp any defence system that the U.S. could realistically deploy. Russia, of course, would be equally powerless against a determined attack from the United States.

While U.S.-Russian equality is some insurance against thermonuclear war, the rise of China as a nuclear power is more frightening. Western intervention in the Far East could look very different with Chinese ballistic missiles covering India, Burma, Thailand, Malaysia, Laos, Cambodia, Vietnam, Korea, the Philippines, Japan—even Australia and New Zealand.

World security could be severely shaken in the Seventies if the threat of nuclear attack were used to back up Communist expansion in this area. China could make smaller countries "nuclear hostages" against Western intervention, Japan would be particu-

"Back Door" Attack

Russia's Fractional Orbit Bombardment System, now being developed, could be used for a "back-door" attack on the United States. The ICBM would be sent into a low orbit to reach the United States by the "reverse route" over the South Pole. When 500 miles (and three minutes) from its objective, a retro-rocket would bring the warhead out of orbit on to its target.

larly vulnerable—and so would any United States task force in neighboring oceans.

The U.S. might be forced to counter by forming nuclear alliances with Japan, Australia and perhaps India and other countries. Or the nations concerned might decide to manufacture their own nuclear weapons. These are the circumstances that the nuclear non-proliferation treaty must somehow inhibit.

Preliminary moves to close the nuclear gap in the Far East are already beginning. One scheme, now under intensive study by the U.S. Navy, is a sea-based anti-ballistic missile system "to protect U.S. bases throughout the world and defend friendly nations threatened by nuclear blackmail."

Russia, too, must evolve new defences. The Sino-Soviet border extends across 3,000 miles of Asia's snows and deserts. It must be protected against possible Chinese expansion into disputed territories in the Soviet Far East and Mongolia.

China's advance to nuclear status has been more rapid than most Western experts expected. Many of her best scientists trained in Russia and the U.S. Dr. Chien Hseuh-shen, who leads top-secret work on missiles, originally was part of the Second World War rocket team at the Jet Propulsion Laboratory in California. He returned to China in 1955 during the witch-hunt era of the late Senator Joseph McCarthy. It must have been in the mid-Fifties that the Peking government took the important decision to develop both the H-bomb and a rocket delivery system.

The first fruit of this plan was a nuclear testing centre at Lop Nor in the Takla Makan Desert in Sinkiang Province. The first nuclear device of about 20 kilotons was exploded on October 16, 1964. Observations made by U.S. Air Force reconnaissance satellites quickly brought in new information—about roads, buildings and launch pads which pinpointed a rocket test site. Within two years of the first atomic test a nuclear bomb had been lobbed nearly 400 miles by a missile to explode at Lop Nor.

Then, on June 17, 1967 came the hydrogen-bomb test which convinced the West that China had found a short cut to a compact thermonuclear warhead.

This and other information available to the Central Intelligence Agency led to urgent re-assessments in the Pentagon. Medium-range nuclear missiles posing a threat to Southeast Asia could be ready in 1970. A modest ICBM force, capable of striking at North America could be on site in 1972, certainly by the mid-Seventies. Adding to the concern were reports from U.S. Naval Intelligence that two G-class diesel-powered submarines at the dockyard of Dairen in southern Manchuria appeared to have three launch tubes for missiles of over 300 miles range.

The potential threat to United States' security came into the open last September when President Johnson ordered into production the $5 billion "thin-line" Sentinel anti-ballistic missile defence system. The first elements—including an advance base on Honolulu—are shown on the world map. Although too lightly dispersed to counter an all-out assault by the Soviet Union, Sentinel will shield the U.S. from "a possible nuclear attack" by Red China when it is fully operational in 1973. For what it is worth, it also helps maintain parity with Soviet anti-ballistic missiles being deployed near Moscow, Leningrad and other centres.

Meanwhile, in Western Europe, Charles de Gaulle is taking France deeper into the "nuclear club" by extending his celebrated Force de Frappe. Already, 62 Mirage 4A aircraft that can extend their range by in-flight refuelling, carry a 60-kiloton bomb apiece. Each bomb has three times the explosive power of the one dropped on Hiroshima.

Later this year, the first French hydrogen bomb should be tested in Polynesia. The developed weapon will be carried by Mer-Sol Balistique Stratégiques missiles of French design and manufacture, 64 of which will be installed in four French-built nuclear-powered submarines. Le Redoutable, launched last year, should be ready in 1969; sister vessels will follow in the early Seventies.

Yet before this fleet is fully operational, de Gaulle will have at his command nests of ballistic missiles based in France itself. The first missile complex will be on the Plateau d'Albion, only about 100 miles from the fashionable beaches of the Côte d'Azur. Sunk into 90-foot silos will be 27 nuclear-tipped rockets of some 2,000 miles range. Each will have the explosive

De Gaulle's Missile Posture: 1969-76

1. First 27 Sol-Sol Balistique Stratégique missile being installed in underground silos on Plateau d'Albion, north of Marseille. Range: 2,000 miles. Nuclear yield: 500 kilotons.

2. Atomic centre at Pierrelatte producing enriched uranium (U-235) for a hydrogen bomb test this year and for missile warheads.

3. Centre d'Essais des Landes near Biscarrosse. Experimental silos for testing missiles over the Atlantic.

4. French nuclear-powered submarine with 16 Mer-Sol Balistique Stratégique missiles of 1,860 miles range; nuclear yield 500 kilotons. LE REDOUBTABLE, operational 1970; LE TERRIBLE 1972, others 1974 and 1976. Possibility of a fifth.

equivalent of 25 Hiroshima bombs. Watching over this lethal brood will be an underground command centre.

Already this costly arms build-up is beginning to place strains on the French economy. Yet still more must be added to make the system effective. As it will operate outside NATO, France must have her own advance warning system of missile attack and a foolproof system of communications linking the High Command (and the President) with missile bases and missile launching submarines. The French advance warning system is now being planned under a top-secret project that is known as Air-70.

Apart from swelling Gaullist pride, what is the Grand Strategy? De Gaulle says the Force de Frappe must be able to strike in every direction because "it is impossible to predict how the great powers will evolve." Another favorite argument is that nuclear weapons (including battlefield missiles) allow reduction in the size of the armed forces. Pierre Messmer, the French defence minister, claims nuclear weapons are less expensive than conventional weapons on this score. This is a dangerous philosophy. Without conventional ground forces, brush-fire wars could grow to nuclear proportions.

The United States and Russia, while finding no way out of their own nuclear impasse, are at one in deploring the spread of nuclear weapons. They are particularly nervous about small nuclear forces which are not linked with the comprehensive advance warning and communications networks available to themselves. An inefficient advance warning system can only increase the dangers of war by miscalculation.

Moreover, small nuclear forces invite a pre-emptive strike. Europe's deterrent forces—British and French —could be among the first to feel the impact of an East-West confrontation.

A recent report prepared for the United Nations and endorsed by Secretary General U Thant leaves no room for argument. Nations that spend money on nuclear arms, it insists, are living in a fool's paradise. ▲

MUNICIPAL (*Continued from page 13*)

and each county has perpetuated a large number of small units with inadequate capability for emergency operations, partial civil defense programs, and inadequate civil defense staffs for planning purposes. A single civil defense structure should be established for metropolitan areas employing a unified civil defense staff and providing for an emergency chain of command over the entire region. This could be based upon an advisory commission of the participating units for planning purposes. The core city should be used as the base for civil defense organization in metropolitan areas, and in rural areas, the county could serve this function. The state office of civil defense could be the agency to define the civil defense areas. This problem, in particular, should be studied in greater depth and a pilot program undertaken to determine its feasibility. ▲

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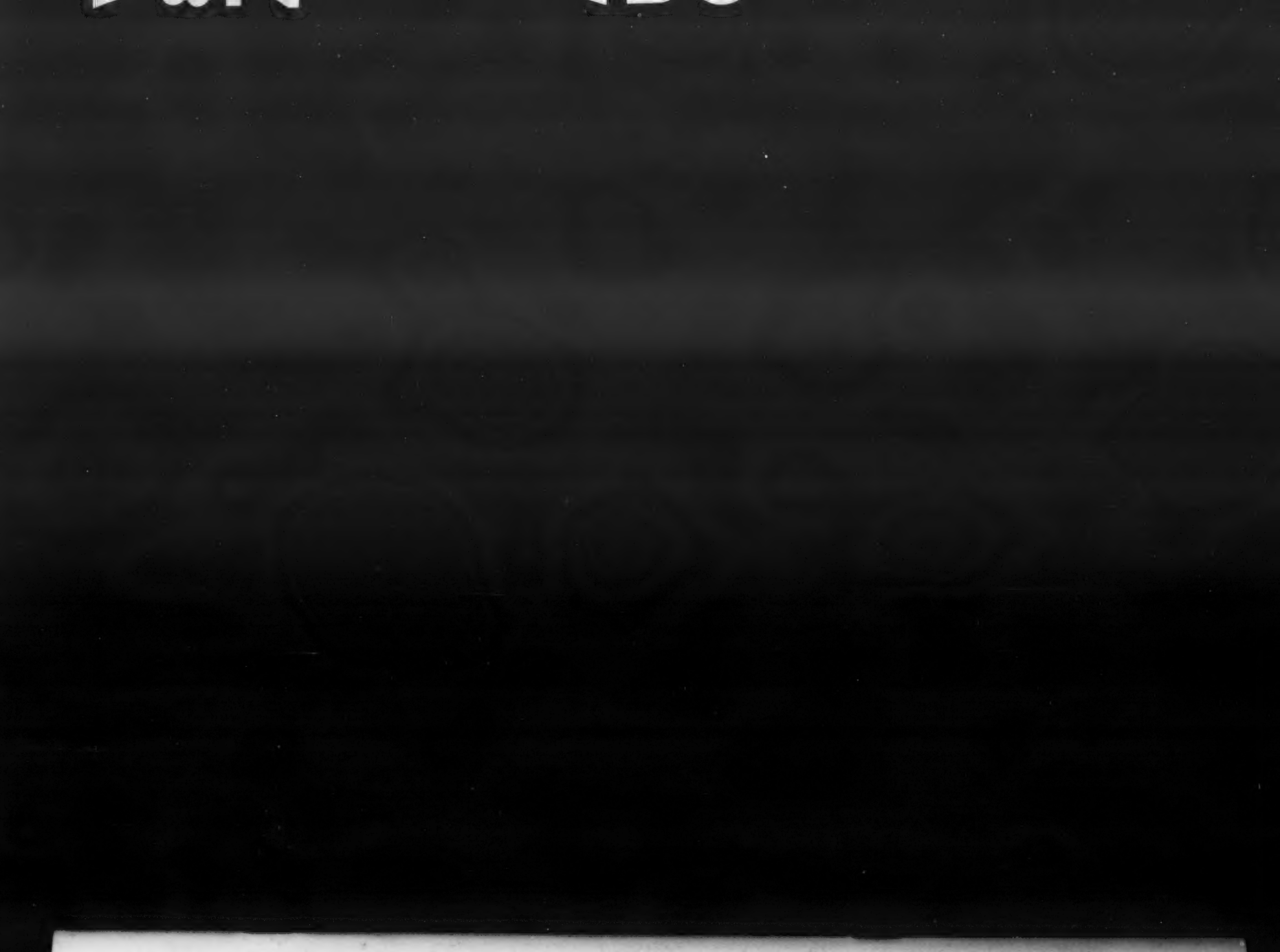
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